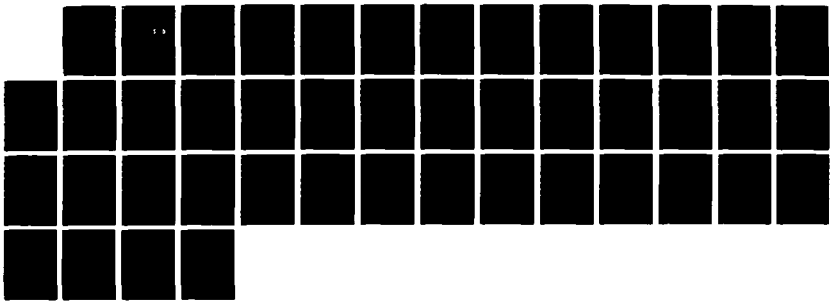
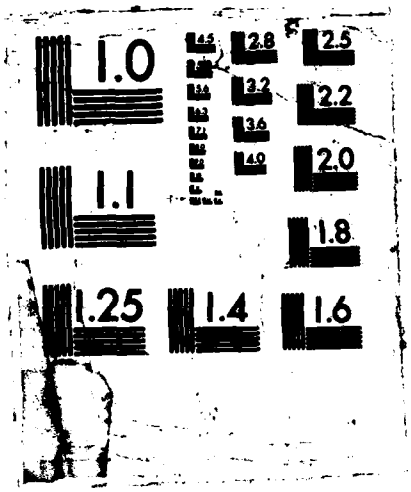
AD-A187 360 MICRO PAVER CONCEPT AND DEVELOPMENT AIRPORT PAVEMENT MANAGEMENT SYSTEM..(U) CONSTRUCTION ENGINEERING RESEARCH LAB (ARMY) CHAMPAIGN IL M Y SHAHIN ET AL. 1/1

UNCLASSIFIED JUL 87 CERL-TR-M-87/12 DOT/FAA/PM-87/8 F/G 5/1 NL




1.0
1.1
1.25
1.4
1.6
2.8
3.2
3.6
4.0
2.5
2.2
2.0
1.8

(2)

AD-A187 360

DOT/FAA/PM-87/ 8

Program Engineering
and Maintenance Service
Washington, D.C. 20591

# Micro PAVER
# Concept and Development
# Airport Pavement Management System



Mohamed Y. Shahin
Kathryn A. Cation
Margaret R. Broten

U.S. Army Construction Engineering
Research Laboratory
P.O. Box 4005
Champaign, IL 61820-1305

July 1987



U.S. Department of Transportation
Federal Aviation Administration

## NOTICE

This document is disseminated under the sponsorship of the Department of Transportation and the U.S. Army Construction Engineering Research Laboratory in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

## NOTICE

The United States Government does not endorse products or manufacturers. Trade or manufacturer's names appear herein solely because they are considered essential to the objective of this report.

Technical Report Documentation Page

| 1. Report No. | 2. Government Accession No. | 3. Recipient's Catalog No. |
|---|---|---|
| DOT/FAA/PM-87/8 | AD-A187360 | |

| 4. Title and Subtitle | 5. Report Date |
|---|---|
| Micro PAVER<br>Concept and Development<br>Airport Pavement Management System | July 1987 |
| | 6. Performing Organization Code |
| | 8. Performing Organization Report No. CERL-TR-M-87/12 |
| 7. Author(s)<br>M. Y. Shahin, K. A. Cation, and M. R. Broten | |
| 9. Performing Organization Name and Address<br>U.S. Army Construction Engr Research Laboratory<br>P.O. Box 4005<br>Champaign, IL 61820-1305 | 10. Work Unit No. (TRAIS) DTFA01-86-Z-02040 |
| | 11. Contract or Grant No. |
| | 13. Type of Report and Period Covered<br>FINAL REPORT |
| 12. Sponsoring Agency Name and Address<br>U.S. Department of Transportation<br>Federal Aviation Administration<br>800 Independence Avenue, S. W.<br>Washington, D.C. 20591 | 14. Sponsoring Agency Code APM-740 |
| 15. Supplementary Notes | |

16. Abstract

This report describes Micro PAVER, a microcomputer version of the PAVER Pavement Maintenance Management System. PAVER is a field-tested, validated pavement maintenance management system for airports, cities, counties, and military installations which is designed to optimize the funds allocated for pavement maintenance and rehabilitation (M&R).

This report discusses the development of the Micro PAVER program and its capabilities in the areas of pavement network inventory, project prioritization, inspection scheduling, determining present and future network condition, determining maintenance and rehabilitation needs, budget planning, and economic analysis.

The Micro PAVER technology is based on the Pavement Condition Index (PCI) survey and rating procedure developed at USA-CERL. The PCI, which is a numerical index from 0 to 100, is a measure of the pavement's structural integrity and operational condition and is computed as a function of distress type, severity, and quantity. The PCI provides an objective and consistent measure of pavement condition.

Micro PAVER provides data and procedures for practical decisionmaking to identify cost-effective maintenance and rehabilitation needs for roads, streets, parking lots, and airfield pavements. The Micro PAVER system shows the effects on the pavement network of performing no major rehabilitation, allows the determination of life cycle costs for various M&R alternatives, and provides a rational and objective basis for evaluating pavement condition and determining M&R needs and priorities.

| 17. Key Words | 18. Distribution Statement |
|---|---|
| Micro PAVER<br>Pavement Condition Index<br>Maintenance Management<br>Pavements | Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161. |

| 19. Security Classif. (of this report) | 20. Security Classif. (of this page) | 21. No. of Pages | 22. Price |
|---|---|---|---|
| Unclassified | Unclassified | 43 | |

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

## FOREWORD

This project was funded under Interagency Agreement No. DTFA01-86-Z-02040 between the U.S. Department of Transportation, Federal Aviation Administration (FAA) and the U.S. Army Construction Engineering Research Laboratory (USA-CERL). The Technical Monitor for this project was Aston McLaughlin, FAA. Additional funding was contributed by the U.S. Army and U.S. Air Force.

The following individuals are acknowledged for the system design and programming of Micro PAVER: E. J. Japel, K. C. Stewart, R. S. Hougland, and T. B. Adams, USA-CERL.

The assistance of the following individuals from the FAA Micro PAVER User's Group is acknowledged and appreciated: Fred Gammon, Bob Kunkel, Jim Jensen, Michael Kennedy, and Mark Arnold, Wisconsin Bureau of Aeronautics; Aston McLaughlin, FAA; Roger Barcus, Jim Bildilli, Dick DeFend, and Daniel Meyers, Illinois Department of Transportation, Bureau of Aeronautics; Jim Hall and Bob Wurtz, Indianapolis Airport Authority; Bill Schnerr, Texas Bureau of Aeronautics; Bob Benko, FAA Great Lakes Region; Steve Smith, Port of Seattle; Michael Haney, Quad City Airport; James Hansford, Central Wisconsin Airport; John Auer, Bill Lyon, Diane Hofer, and Chris Koenig, Nebraska Bureau of Aeronautics.

The additional assistance of the following individuals in reviewing the Micro PAVER test version is acknowledged and appreciated: Bob Lubbert, Paul Styer, and Amita Narielwala, Facilities Engineering Support Agency; Bob Williams, Headquarters, U.S. Army Corps of Engineers, Stuart Millard, U.S. Air Force; Ross Bentsen, U.S. Army Waterways Experiment Station; and Jim Ewing, American Public Works Association.

The work was performed by the Engineering and Materials (EM) Division, U.S. Army Construction Engineering Research Laboratory (USA-CERL). Dr. R. Quattrone is Chief of EM.

COL Norman C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

## CONTENTS

## FIGURES



## TABLE

# PAVEMENT MAINTENANCE MANAGEMENT: THE MICRO PAVER SYSTEM

## 1 INTRODUCTION

### Objective

The objective of this work was to develop an airport Pavement Management System (PMS) for use on IBM*-compatible personal computers. Funded primarily by the Federal Aviation Administration (FAA), the system was to be tailored after the mainframe PAVER system now used by the U.S. Army, Air Force, Navy, and the American Public Works Association (APWA).

The objective of this report is to introduce the PMS concepts used in the Micro PAVER program. The use of Micro PAVER as a tool in prioritizing projects, scheduling inspections, determining present and future network condition, determining maintenance and rehabilitation needs, budget planning, and economic analysis will also be discussed.

### Background

Experienced pavement engineers have acknowledged that the life of a well maintained pavement could be two or three times longer than that of a poorly maintained one. In the past several years, many agencies have directed research toward developing Pavement Management Systems to select the most cost-effective Maintenance and Repair (M&R) alternatives and identify the optimal time of application. In September 1982, the FAA published an Advisory Circular, AC 150/5380-6, which outlined the procedures and guidelines for airport pavement maintenance. The pavement condition rating used in these guidelines is the Pavement Condition Index (PCI) developed by the U. S. Army Construction Engineering Research Laboratory (USA-CERL) and implemented by the Army and Air Force to monitor the condition of their airfield pavements. The PCI is the foundation for the Pavement Maintenance Management System known as PAVER.

PAVER was developed by USA-CERL under the auspices of Headquarters, U.S. Army Corps of Engineers (HQUSACE) through funding from the Army and Air Force. It was designed to operate on mainframe computers for use by military installations, municipalities, airports, and counties, and was adopted by the APWA. PAVER was field tested and validated at Fort Eustis, Virginia, through a full-scale implementation monitored by 21 pavement engineers. In the past 10 years, it has been implemented, or is in the process of being implemented, at over 60 military installations and 45 municipalities. Details of the system's development and the results of an economic analysis of its implementation have been documented.[1]

---

*IBM is a registered trademark of International Business Machines.

[1] M. Y. Shahin and S. D. Kohn, Pavement Maintenance Management for Roads and Parking Lots, Technical Report M-294/ADA110296 (U.S. Army Construction Engineering Research Laboratory, October 1981); M. Y. Shahin and S. D. Kohn, Overview of the "PAVER" Pavement Management System and Economic Analysis of Field Implementing the "PAVER" Pavement Management System, Technical Manuscript M-310/ADA116311 (U.S. Army Construction Engineering Research Laboratory, March 1982).

## Approach

In the beginning of Fiscal Year 1985, through funding from FAA and in response to the rapid technological improvements in the microcomputer industry, the increased use of the microcomputer in management, and the often prohibitive mainframe PAVER costs for small data base users, USA-CERL began to develop an airport PMS for use on IBM-compatible personal computers. The system was intended to be similar to the mainframe PAVER program, and was to meet the following minimum requirements:

1. Use the FAA guidelines[2] to divide airfield pavements into uniform sections and to perform the PCI procedure.

2. Store the pavement condition history based on the PCI method.

3. Store the pavement construction and maintenance history.

4. Store the nondestructive deflection test results necessary to determine overlay design thicknesses.

5. Generate reports at the airport network level for budget planning, inspection scheduling, and determining overall pavement condition at any given time.

6. Allow for project level analysis (including determining M&R requirements and costs) and perform economic analysis among the various maintenance alternatives.

The level at which the requested system was to meet the above requirements was to be limited only by the capabilities of currently available commercial microcomputers. To help collect input data and to assure the usability of the final product, a "user's group" was to be established which was to consist of various state and local airport authorities whose primary responsibility would be to assist in the direction of the program development.

This report denotes completion of this task. Version 1.0 of the Micro PAVER Pavement Maintenance Management System has been released to program sponsors at FAA and is being distributed to users through the APWA and the University of Illinois Pilot Strategic Support Center (PSSC).

USA-CERL continues to develop technological improvements and additional capabilities for the program. Updated versions of the program and corresponding documentation will become available to Micro PAVER users as improvements are completed.

## Mode of Technology Transfer

The Micro PAVER program has potential application in both the military and civilian communities. The program is available to users through the APWA and the University of Illinois PSSC. The Micro PAVER program will be incorporated into the Pavement Management Short Course cosponsored by the University of Illinois, Department of Civil Engineering; USA-CERL; and the Facilities Engineering Support

[2]Advisory Circular (AC) 150/5380-6 Guidelines and Procedures for Maintenance of Airport Pavements (Federal Aviation Administration, December 1982).

Agency (FESA) in the Spring of 1987. Military use of the PAVER and Micro PAVER systems will be incorporated into the revision of Army Regulation (AR) 420-72[3] and Technical Manual (TM) 5-623[4]. As additional capabilities and/or technologies are added to the Micro PAVER program, updated versions of the program and corresponding documentation will be made available.

[3]Army Regulation (AR) 420-72, Facilities Engineering Surfaced Areas, Railroads and Associated Structures (Headquarters, Department of the Army, 24 March 1976).

[4]Technical Manual (TM) 5-623, Pavement Maintenance Management (Headquarters, Department of the Army, November 1982).

## 2 PAVEMENT MAINTENANCE MANAGEMENT CONCEPTS

As the cost of rehabilitating and repairing the pavement infrastructure in the United States continues to escalate, the civil engineering community has begun to focus its attention on developing tools to assist in the cost-effective management of their M&R dollars. USA-CERL recognized this need as early as 1968 and began developing the PAVER Pavement Maintenance Management System. The maintenance management concepts presented in this chapter were generated during the development of the PAVER system and are used in both the PAVER and Micro PAVER programs.

### Approaches to Determining Facility M&R Needs

Various agencies in the United States use different approaches to determine the necessary maintenance and rehabilitation for a given facility. This section briefly describes the three most common approaches.

Many agencies use the "ad hoc" approach. In this approach, the agency staff applies the M&R alternative that their experience suggests is the best solution. Evaluation suggests that this approach results in the seemingly habitual application of a few selected alternatives. A major drawback to this approach is that because of the limited set of alternatives, the best or most economical option for the facility under consideration may not be selected.

The second approach is the "present condition" approach. In this approach, the facility is first evaluated by means of various condition indicators. Based on an analysis of these indicators, an M&R alternative is selected to address the condition; however, no life-cycle cost comparisons of the alternatives are considered. A major advantage of this approach is that the prescribed M&R alternative directly addresses the deficiencies found in the facility. The disadvantage is that the choice may not be the most cost-effective method.

The preferred "life-cycle" approach requires not only an indepth evaluation of the facility under consideration, but a prediction of its future condition. This ensures selection of the most economical M&R alternative, as determined on a life-cycle cost basis. Predicting the future condition requires the ability to measure the condition on an objective, repeatable scale, such as the Pavement Condition Index (PCI) shown in Figure 1.*

The PCI, a numerical index from 0 to 100, is a composite index of a pavement's structural integrity and operational condition. It was developed to agree closely with the collective judgment of experienced airfield pavement engineers and is based on an objective measurement of distress type, severity, and quantity. The PCI is repeatable within 5 points, with 95 percent confidence, and has been mandated by the Air Force for selecting M&R projects and adopted by the FAA for use by civilian airports.[5] By projecting the rate of change on such a condition scale, a meaningful life-cycle cost analysis can be performed to compare the various M&R alternatives and the future maintenance costs associated with each. Not only is the best M&R alternative selected, but the optimal time of application is also determined.

---

*Figures and tables are listed beginning on page 14.

[5] FAA Advisory Circular 150/5380-6.

This is critical to avoid higher M&R costs caused by excess deterioration. Figure 2 shows the typical condition deterioration of a facility and the relative cost of rehabilitation at various points throughout its life. The illustration clearly shows that the optimum time for rehabilitation is when deterioration begins to occur at a much faster rate than when the facility was initially constructed.

**Project vs Network Maintenance Management**

Selecting M&R alternatives for a given project is known as project-level analysis. Each project is analyzed and the best alternative selected, regardless of the needs of other projects. Engineers have always been trained to work at the project level, which may be acceptable as long as money is abundant. However, money for M&R is often not abundant. Top management is now demanding fiscal year budget projections that consider the agency's entire network. This cannot be done with current resources if an indepth evaluation must be completed for each project before preparing required budgets. Instead, each facility must be inspected in less detail and at a faster rate before projects are identified. This is referred to as network-level inspection. After a facility is selected as a candidate project, it is scheduled for an indepth evaluation and selection of a specific strategy.

**Components of Maintenance Management Systems**

This section describes the generic maintenance management components developed for PAVER and applied to the Micro PAVER program development. These components, shown in Figure 3, are also being used to develop systems for built-up roofing, railroads, and other civil works structures.

The first step is to determine what is being managed. This simply means developing a network inventory, such as the number and area of pavement sections that the agency is responsible for maintaining. The pavement network should be divided into sections that represent the minimum fraction for which major M&R decisions are required. For example, the pavement on one street may be divided into three sections, based on construction history, pavement structure, and traffic. The inventory can also be used to store each section's physical dimensions. More importantly, the inventory should include the condition of each section in the network.

Although developing the network inventory is one of the most tedious steps in initiating a maintenance management system, it is the most crucial step because it establishes the foundation for the system. Once the network inventory is correctly prepared, it need not be repeated.

Without an efficient filing system, massive data collection can only lead to confusion and waste of resources. For a small network, a manual filing system could probably be established. However, with the current advances in technology, the use of computerized data bases for easy data storage and access is within the reach of every agency. When storing data, every effort should be made to ensure the data are accurate. Data should be reviewed and screened before being entered into the data base, and checked again after their entry to ensure data integrity.

Developing the network inventory and establishing the data base represent the major effort required to initiate a maintenance management system. The remaining components represent the payoff from these efforts.

In network analysis, current and future needs are determined at the network level. The most important step in accurately analyzing network needs is projecting the future condition of each section. This projection provides the input needed to perform two tasks: (1) identify the future frequency of inspection for various sections, and (2) identify sections requiring major M&R in future years.

Identifying the inspection frequency depends not only on the absolute or minimum allowable condition of a given section, but also on each section's rate of deterioration. Sections with higher deterioration rates should be scheduled for more frequent inspection. Determining which sections require major M&R in future years can be based on the section's minimum allowable conditions. Another sophisticated approach is based on optimization techniques that ensure least cost or maximum benefit/cost ratio for the agency while meeting certain minimum condition management constraints. The actual budget for each future year can then be determined based on the average relation between condition and M&R cost.

As the maintenance management system is put to use, identified future budget needs are likely to be a significant input toward allocating the current year's budget. Comparing the agency's prioritization preference with the actual budget then produces a list of potential projects that are candidates for M&R in the current program year. This then provides the link with project-level analysis.

In the project-level analysis, each section identified in the network analysis as a candidate for M&R in that year should be subjected to a detailed condition survey, including destructive and nondestructive testing as needed. The results of these detailed surveys are then used to select M & R alternatives which prevent the recurrence of the distresses identified. In addition, the condition of adjacent sections should be reviewed to determine if it would be economical to combine various sections into one. The various identified alternatives, including no action, should be compared on a life-cycle cost basis. The results, combined with budget and management constraints, will produce the current year's final M&R program.

# 3 DEVELOPMENT AND CAPABILITIES OF THE MICRO PAVER PROGRAM

## Developmental Phases

Micro PAVER development was broken down into three separate phases: (1) preliminary data base and report development, (2) field testing, and (3) final development. The entire project, including field testing, was scheduled to be completed in October 1986. Details relating to the completion of each phase of the project and the resulting capabilities of the program are included in this chapter.

The first developmental phase consisted of three primary tasks: selection of a data base manager, data element definition, and preliminary report development. Instead of requiring Micro PAVER users to purchase a particular commercial data base manager (and because the program was to be distributed without royalty), USA-CERL developed a data base manager. Microrim, Inc. agreed to allow USA-CERL to use Microrim's R:base 5000 Program Interface as the structure to build the data base on. This method enables the user to run the Micro PAVER program without purchasing any R:base products.

Once the data base manager was established, the program's data elements could be defined. Input from the Micro PAVER User's Group was critical throughout this task. Applicable data elements used in the mainframe PAVER were identified and, in many cases, modified for Micro PAVER due to recommendations by the FAA User's Group.

Five data entry options allow organized filing and storage of the data elements. A listing of each option and the corresponding data elements included in Version 1.0 of the Micro PAVER program is included in Table 1. As program development continues, additional data elements, including traffic, material properties, and work requirements will be added.

The final task in the first phase was to develop the computer reports. Based on the mainframe PAVER report capabilities documented in the PAVER Reference Manual[6] and Air Force Manuals[7], the Micro PAVER reports were modified to make report generation easier and present information to the user in a clear, straightforward manner. The capabilities of each report included in Version 1.0 of the Micro PAVER program are described later in this chapter. Sample outputs for each report are also presented.

After the first phase of program development was completed, a test version of Micro PAVER was prepared. The test period was May 1986 through the end of July 1986. The Micro PAVER User's Group, FESA, USAHQCE, U.S. Army Waterways Experiment Station, and the APWA participated in the test.

Before receiving the test program, test participants attended a workshop to familiarize themselves with the program. They were given hands-on experience on all aspects of the program, including data entry and report generation.

---

[6] M. Y. Shahin and K. A. Cation, PAVER Reference Manual, ADP-356-2 (U.S. Army Construction Engineering Research Laboratory and U.S. Army Facilities Engineering Support Agency, 1986).

[7] M. Y. Shahin, S. D. Kohn, M. I. Darter, and T. D. James, "Development of a Pavement Maintenance Management System, Volumes I through X," (November 1976 through June 1984).

After receiving the program, each participant was to comment on the technical accuracy, ease of use, usefulness of the product, and additional features desired. To help users during the test period, a User's Guide was drafted and included in the test as an item for comment and review. Comments were to be sent to the system developers at USA-CERL by the end of July 1986 for possible inclusion in Version 1.0 scheduled to be released in October that year.

During the final phase of program development, additions and/or changes requested by the users were incorporated into the program. The final product was Micro PAVER, a user-friendly, modified version of the mainframe PAVER program, and the corresponding User's Guide which were released to the FAA in October, 1986. Widespread distribution of the program was scheduled to begin early in 1987.

**Program Capabilities**

The Micro PAVER Pavement Maintenance Management System is an effective tool for identifying M&R needs and the optimal time of M&R application. Version 1.0 capabilities include data storage and retrieval, pavement network inventory, project prioritization, determining present and future network condition, budget planning, inspection scheduling, determining M&R needs, and economic analysis. In this section, each Micro PAVER report is discussed in detail. A sample output from each is included.

Ten reports were included in the first version of the Micro PAVER program. Each report can be customized by the user so that only the particular pavements of interest are included and the information is organized according to the user's needs. For information on how to use these features, refer to the Micro PAVER User's Guide.[8]

*Pavement Network Inventory*

An agency's pavement network consists of all surfaced areas that provide accessways for ground or air traffic; including roads and streets, parking areas, runways, taxiways, and aprons. Before entering data in a Micro PAVER data base, the pavement network must be divided according to the guidelines established in FAA Advisory Circular AC 150/5380-6. In summary, the following divisions must be made:

1. Branch (Facility): A branch is defined as a part of the pavement network. It is a single entity and has a distinct function. Typically, a separate branch is identified for each runway, taxiway, or apron on an airfield, and each road or street for a municipality.

2. Section (Feature): A section is defined as a division of a branch. It has consistent characteristics throughout its entire length or area. Important characteristics to consider include structural composition, construction history, traffic, and condition.

3. Sample Unit: Each section is divided into smaller units, called sample units, for pavement condition inspections. The recommended size for sample units on short jointed concrete pavements (less than 30 ft between joints) is approximately 20 slabs. The recommended size for asphalt concrete pavement sample units is approximately 2,500 sq ft for roads and streets, and 5,000 sq ft for airfield pavements.

[8]Micro PAVER User's Guide, Version 1.0 (U.S. Army Construction Engineering Research Laboratory, October 1986).

Network inventory information is stored in the Micro PAVER data base for each defined branch and section. Two reports provide a list of the stored data. The List Report (Figure 4) identifies the branch number, branch name, and number of sections in each of the branches requested by the user.

The Inventory Report (Figure 5) provides inventory information at the section level. For each section requested by the user, branch and section number, branch name, branch use, section category, zone, area, and surface type will be furnished.

*Project Prioritization*

Once PCI condition survey data have been entered into the Micro PAVER data base, pavement sections can be sorted and prioritized according to their need for M&R work. The PCI Report (Figure 6) can be used to assist in ranking pavement sections. This report provides both branch and section information including the last construction date, last inspection date, pavement age, and latest PCI. Similar types of pavements can be grouped together by common characteristics, such as branch use and functional classification, and ranked within those groups from lowest to highest PCI. Based on the agency's prioritization scheme, such as the one shown in Figure 7, M&R funding dollars can be allocated to each pavement group.

*Determination of Present and Future Network Condition*

The PCI Frequency Report (Figure 8) provides the user with an indication of overall network condition, based on the PCI scale, for any year(s) requested. This projected condition can be used to assist in planning future M&R needs and to inform management of present and future network conditions. Future conditions are currently predicted by a straight line extrapolation technique (Figure 9) for all Micro PAVER reports. The maximum slope from either the last inspection or last construction date is used to predict future PCIs assuming no major repairs (such as slab replacement or overlay) have occured between the last inspection and prediction dates. This allows the user to identify the impact on overall network condition of performing no major repairs. Improved prediction techniques based on comprehensive pavement family behavior characteristics have been developed at USA-CERL and will be incorporated into the Micro PAVER program in a future program update.

*Budget Planning*

The Budget Planning Report (Figure 10) is used to produce a 5-year estimate for planning the annual expenditures required to maintain pavements above a user-specified condition level. The user inputs the minimum acceptable PCI level for various branch use/pavement rank combinations, and the unit costs of repair for a particular surface type and PCI condition range. Inflation rates can be input and varied to demonstrate their effect on budget needs. The Budget Planning Report predicts, for each pavement section selected, the year in which the minimum PCI is reached and calculates the cost of repair.

*Inspection Scheduling*

The Inspection Schedule Report (Figure 11) is used to prepare a 5-year plan of the list of pavement sections which should be inspected each year based on minimum acceptable PCI condition level and rate of deterioration. For each branch use/pavement rank combination being considered, the user inputs the PCI value below which condition inspections should be performed. The user also inputs the maximum number of years

between inspections for four different pavement deterioration rates (loss of PCI points per year).

*Determination of M&R Needs*

Several reports are available to help the user determine the M&R needs of a pavement section. The latest PCI and predominant cause of distress (structural, climatic, etc.) are required for the M&R decisionmaking process. The pavement section's rate of deterioration would also be useful. The Condition History Report (Figure 12) provides the user with a plot of PCI over time for a particular pavement section. The plot shows the PCI at each inspection date and extrapolates a point 5 years beyond the last inspection date.

If routine maintenance such as crack filling or spall repair is all that a particular pavement section needs, the M&R Report can be used to estimate the type and cost of routine repair based on a maintenance policy input by the user. The M&R Report (Figure 13) can also be used to compute the cost of applying an overlay after repairing distress. Similar to the M&R Report which applies a maintenance policy to a particular section, the Network Maintenance Report (Figure 14) allows the application of a maintenance policy to all, or a portion, of the pavement network. This report can be used to estimate the type and cost of routine repair across the entire network for annual work plans, or on a section by section basis.

Both the M&R and Network Maintenance Reports are based on the agency's maintenance policy which is stored in the Micro PAVER data base. An example of a maintenance policy is shown in Figure 15. For each pavement section being considered, the reports access the most recent condition distress information, select the routine repair techniques recommended in the agency's maintenance policy, and display both the type of repair and the cost required to perform it.

*Economic Analysis*

For any given pavement section, several repair alternatives may be considered feasible. The Economic Analysis Report (Figure 16) can be used to analyze these alternatives on a life-cycle cost basis and select the most cost-effective alternative. The user inputs initial costs, periodic maintenance costs, and one-time future maintenance costs. The Economic Analysis Report provides the user with the initial cost and equivalent uniform annual cost per square yard. The program allows the user to vary interest rates, repair costs, and timing so that their effect on the alternatives can be analyzed.

# 4 MICRO PAVER IMPLEMENTATION

Version 1.0 of the Micro PAVER program was released to the Federal Aviation Administration in October 1986. Program distribution began early in 1987. In this chapter, system requirements for the program, distribution plans, and future developments will be discussed.

## System Requirements

The Micro PAVER program was designed for IBM-compatible personal computers. A hard disk drive, with a recommended 20 MB or more storage capacity, is required. In addition, 640K Random Access Memory (RAM) is necessary to operate this program. Version 2.0 (or higher) of MS-DOS is the required operating system.

## Distribution

The Micro PAVER program is currently being distributed through two user support centers: the APWA and the PSSC, established by USA-CERL and currently operated by the University of Illinois, Office of Continuing Education. Each center will be providing the same updated version of the program and User's Guide, but will be providing different types of support to users for slightly different fees.

Addresses for the Support Centers are:

American Public Works Association
1313 E. 60th Street
Chicago, Illinois 60637
(312) 667-2200

Pilot Strategic Support Center
University of Illinois
Office of Continuing Education
302 E. John Street
Champaign, Illinois 61820
(217) 333-2882

## Future Developments

The development of new capabilities for the Micro PAVER program continues at USA-CERL. As additions or new techniques are completed, updated versions of the program will be made available to users. The following additions are expected to be added to the program soon:

- Database Additions

  Traffic
  Work Requirements
  Material Properties

- Data Entry/Modification

  Ability to Change Key Fields (e.g., Branch Number, Section Number)

- New Reports

  Inspection Summary
  Nondestructive Deflection Testing (NDT)
  Traffic
  Work Requirements
  Material Properties

- New Technology/Reports

  Graphics
  Family Deterioration Curves
  Preventive Maintenance
  Combined Budget/Frequency Report
  Optimization

## 5 SUMMARY

This report documents the development of Version 1.0 of the Micro PAVER Pavement Maintenance Management Program. Micro PAVER is based on the concepts used in the mainframe PAVER System and can be used to optimize the allocation of M&R funds at airports, cities, counties, and military installations.

The background development of the PAVER System and the application of the same maintenance management concepts in the Micro PAVER program were discussed. Details documenting the phases which comprised the development of the Micro PAVER program were outlined, and a description of the current capabilities of the program including pavement network inventory, project prioritization, determination of present and future network condition, budget planning, inspection scheduling, determination of M&R needs, and economic analysis was presented. Additional capabilities being developed for the program at USA-CERL were also discussed. As these developments are completed, they will be incorporated into future versions of the Micro PAVER program. Finally, the system requirements for operating the program, and the sources for obtaining the copies of the program were presented.

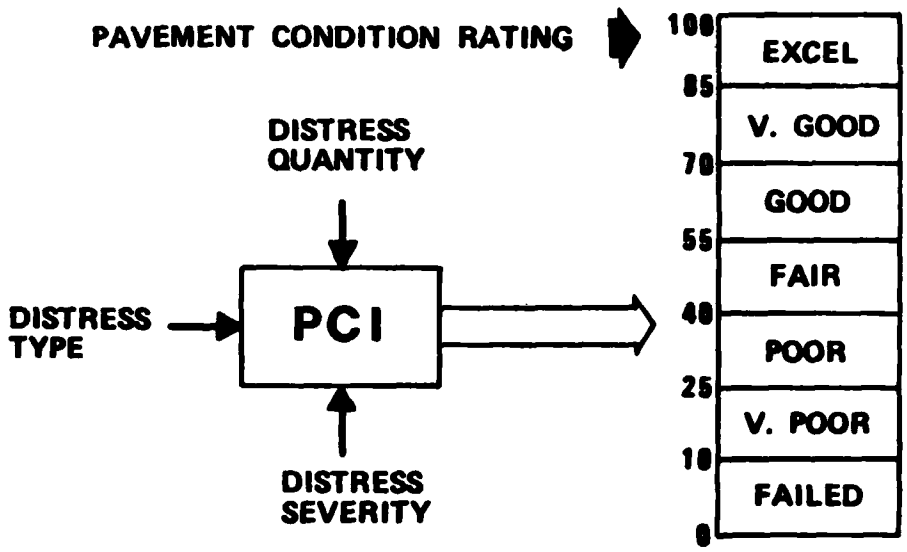



FIGURE 1. PAVEMENT CONDITION INDEX (PCI).

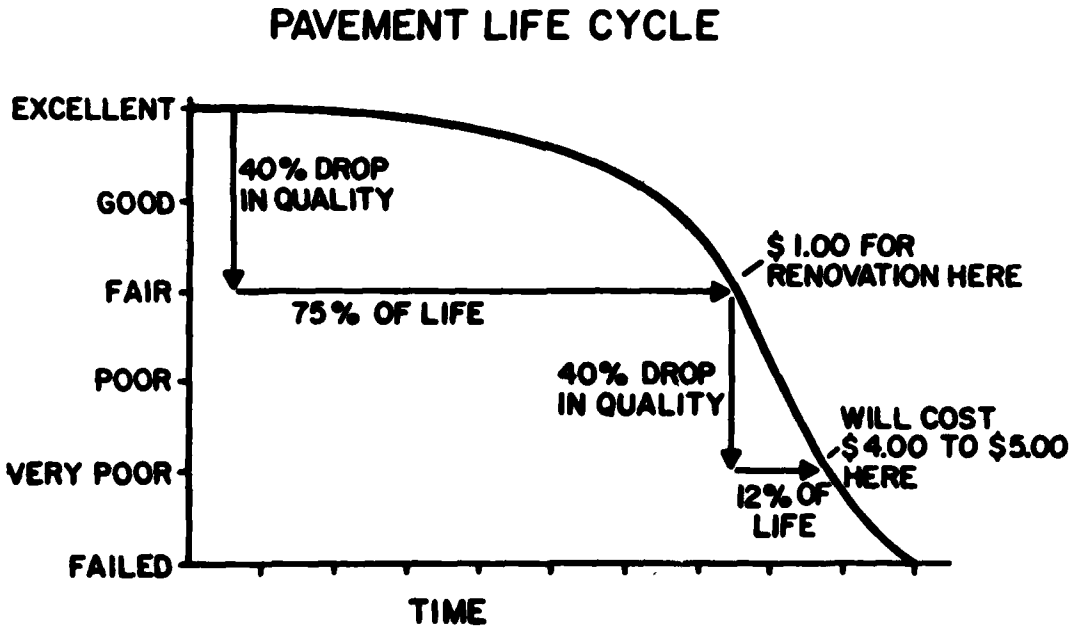



FIGURE 2. TYPICAL PAVEMENT CONDITION LIFE CYCLE.

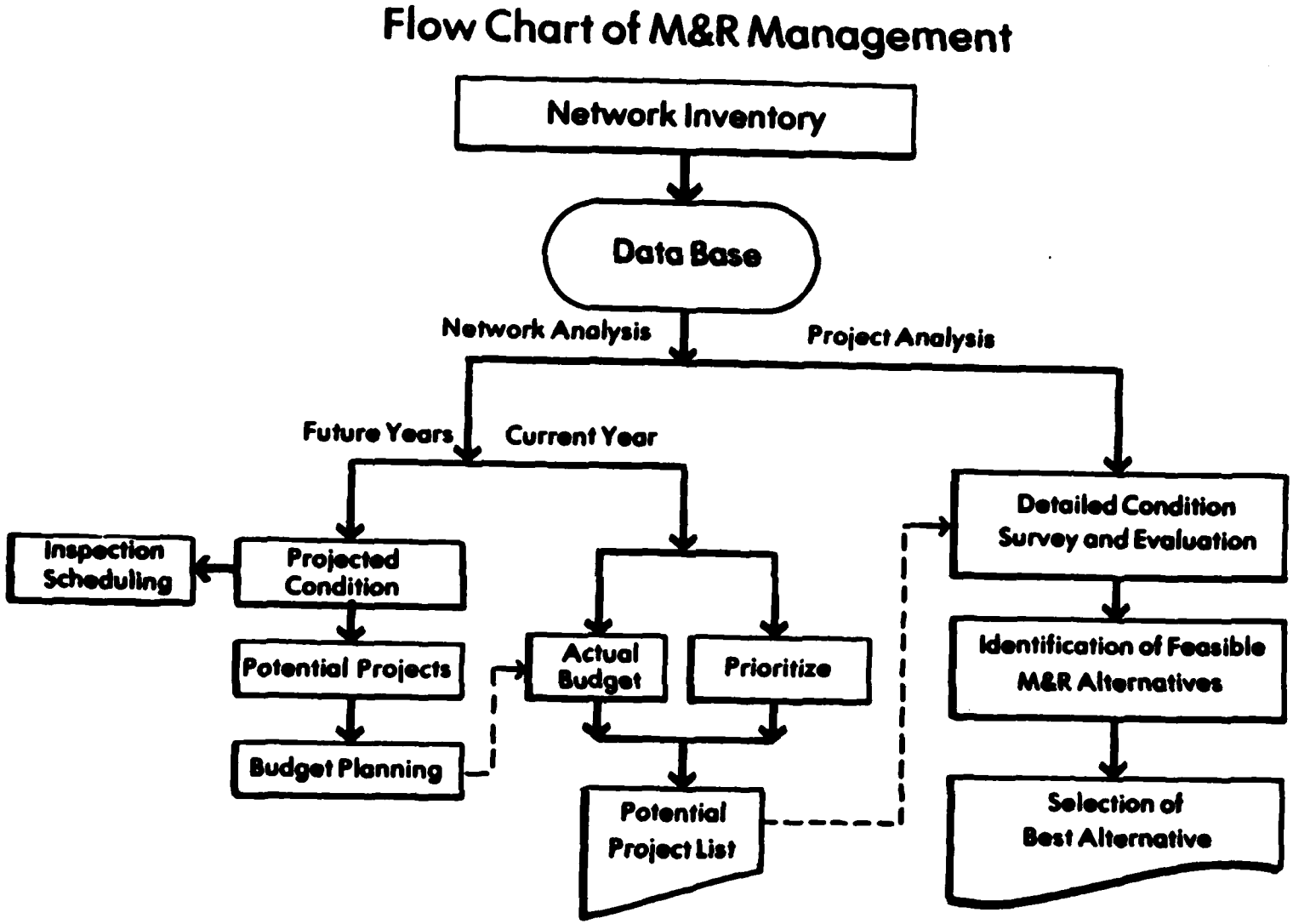



FIGURE 3. COMPONENTS OF MAINTENANCE MANAGEMENT SYSTEMS.

## TABLE 1. MICRO PAVER DATA ELEMENTS

### Branch Definition

| | |
|---|---|
| Branch Number | 5 Alpha-Numeric |
| Branch Name | 25 Alpha-Numeric |
| Branch Use | 7 Alpha-Numeric |
| Number of Sections | 4 Integer |
| Branch Area | 8 Integer |
| Remarks | 70 Alpha-Numeric |

### Section Definition

| | |
|---|---|
| Section Number | 3 Alpha-Numeric |
| From | 25 Alpha-Numeric |
| To | 25 Alpha-Numeric |
| Zone | 4 Alpha-Numeric |
| Section Category | 1 Alpha-Numeric |
| Pavement Rank | 1 Alpha-Numeric |
| Surface Type | 3 Alpha-Numeric |
| Section Length | 4 Integer |
| Section Width | 4 Integer |
| Section Area | 9 Integer |
| Last Construction | Date |
| Slab Length | 4 Real |
| Slab Width | 4 Real |
| Number of Slabs | 6 Integer |
| Joint Length | 7 Integer |

### Inspection Data

| | |
|---|---|
| Inspection Date | Date |
| Riding Quality | 3 Alpha-Numeric |
| Safety | 3 Alpha-Numeric |
| Drainage Condition | 3 Alpha-Numeric |
| Shoulder Condition | 3 Alpha-Numeric |
| Overall Condition | 3 Alpha-Numeric |
| FOD | 3 Alpha-Numeric |
| Total Number of Samples | 3 Integer |
| Sample Number | 3 Alpha-Numeric |
| Sample Type | 1 Alpha-Numeric |
| Sample Unit Size | 8 Integer |
| Distress Code | 4 Integer |
| Distress Severity | 1 Alpha-Numeric |
| Distress Quantity | 4 Integer |

## TABLE 1. (CONT'D)

Work History

| | |
|---|---|
| Work Type | 5 Alpha-Numeric |
| Completed | Date |
| Manner of Accomplishment | 1 Alpha-Numeric |
| Quantity | 10 Real |
| Total Costs | 7 Integer |
| Material Type | 3 Integer |
| Thickness | 5 Real |
| Remarks | 70 Alpha-Numeric |

Maintenance Policy

| | |
|---|---|
| Policy Number | 3 Integer |
| Policy Description | 30 Alpha-Numeric |
| Distress Code | 4 Integer |
| Distress Severity | 1 Alpha-Numeric |
| Work Type | 5 Alpha-Numeric |

NDT

| | |
|---|---|
| Location | 4 Integer |
| Station | 7 Real |
| Date | Date |
| Temperature | 5 Real |
| Load | 6 Integer |
| Maximum Deflection | 7 Real |
| Basin Area | 6 Real |
| DSM | 6 Real |
| Load Transfer | 3 Integer |

BRANCH LISTING REPORT

REPORT DATE: SEP/22/1986

AGENCY NUMBER: USA-CERL

| BRANCH NUMBER | BRANCH NAME | BRANCH USE | BRANCH AREA (SF) | NUMBER OF SECTIONS |
|---|---|---|---|---|
| TWS | TAXIWAY W-2 | TAXIWAY | 200000 | 3 |
| R1230 | RUNWAY 12-30 | RUNWAY | 500000 | 12 |
| A2 | SOUTH APRON | APRON | 100000 | 3 |
| 1L19R | RUNWAY | RUNWAY | 400000 | 9 |
| | | TOTALS | 1200000 | 27 |

**FIGURE 4. LIST REPORT.**

INVENTORY REPORT

AGENCY NUMBER:

REPORT DATE: AUG/27/1986

| BRANCH NUMBER/USE/ NAME | | SECTION NUMBER | SECTION CATEGORY | ZONE | PAVEMENT RANK | SURFACE TYPE | AREA (SF |
|---|---|---|---|---|---|---|---|
| A2 / APRON / SOUTH APRON | FROM: A | AC | N | TO: C | PRIMARY | PCC | 300000 |
| | | | | | TOTAL AREA: | | 300000 |
| MAPLE / ROADWAY/ MAPLE CT | FROM: LK PK RD | 001 | | TO: END OF COURT | PRIMARY | PCC | 5000 |
| | | | | | TOTAL AREA: | | 5000 |
| R1230 / RUNWAY / RUNWAY 12-30 | FROM: SAMPLE UNIT 1 | A1 | N | TO: SAMPLE UNIT 22 | PRIMARY | PCC | 219500 |
| | FROM: SAMPLE UNIT 23 | B1 | N | TO: SAMPLE UNIT 55 | PRIMARY | PCC | 219500 |
| | | | | | TOTAL AREA: | | 439000 |
| R1331 / RUNWAY / RUNWAY 13-31 | FROM: B1 | B1 | N | TO: B43 | PRIMARY | AC | 175000 |
| | | | | | TOTAL AREA: | | 175000 |
| R1836 / RUNWAY / RUNWAY 18-36 | FROM: 0 | A1 | A | TO: 1500 | PRIMARY | PCC | 285000 |
| | | | | | TOTAL AREA: | | 285000 |

**FIGURE 5. INVENTORY REPORT.**

PCI REPORT

REPORT DATE: AUG 27/1986

AGENCY NUMBER:

| BRANCH NUMBER/USE/ NAME | SECTION NUM/RANK/SURF/AREA(SF) | LAST CONSTRUCT DATE | LAST INSPECTION DATE | PCI |
|---|---|---|---|---|
| A2 / APRON<br>SOUTH APRON | AC / P / PCC / 200000<br>CAT: N ZONE: | SEP/30/1962<br>AGE (YRS): .0 | SEP/30/1962 | 100 |
| MAPLE / ROADWAY<br>MAPLE CT | 001/ P / PCC / 5000<br>CAT: ZONE: | APR/30/1976<br>AGE (YRS): 10.1 | MAY/19/1986 | 37 |
| R1230 / RUNWAY<br>RUNWAY 12-30 | A1 / P / PCC / 219500<br>CAT: N ZONE: | SEP/30/1962<br>AGE (YRS): 23.9 | JUL/11/1986 | 39 |
| R1230 / RUNWAY<br>RUNWAY 12-30 | B1 / P / PCC / 219500<br>CAT: N ZONE: | SEP/30/1962<br>AGE (YRS): .0 | SEP/30/1962 | 100 |
| R1331 / RUNWAY<br>RUNWAY 13-31 | B1 / P / AC / 175000<br>CAT: N ZONE: | JUN/15/1975<br>AGE (YRS): .0 | JUN/15/1975 | 100 |
| R1836 / RUNWAY<br>RUNWAY 18-36 | A1 / P / PCC / 225000<br>CAT: A ZONE: | AUG/15/1972<br>AGE (YRS): .0 | AUG/15/1972 | 100 |

**FIGURE 6. PCI REPORT.**

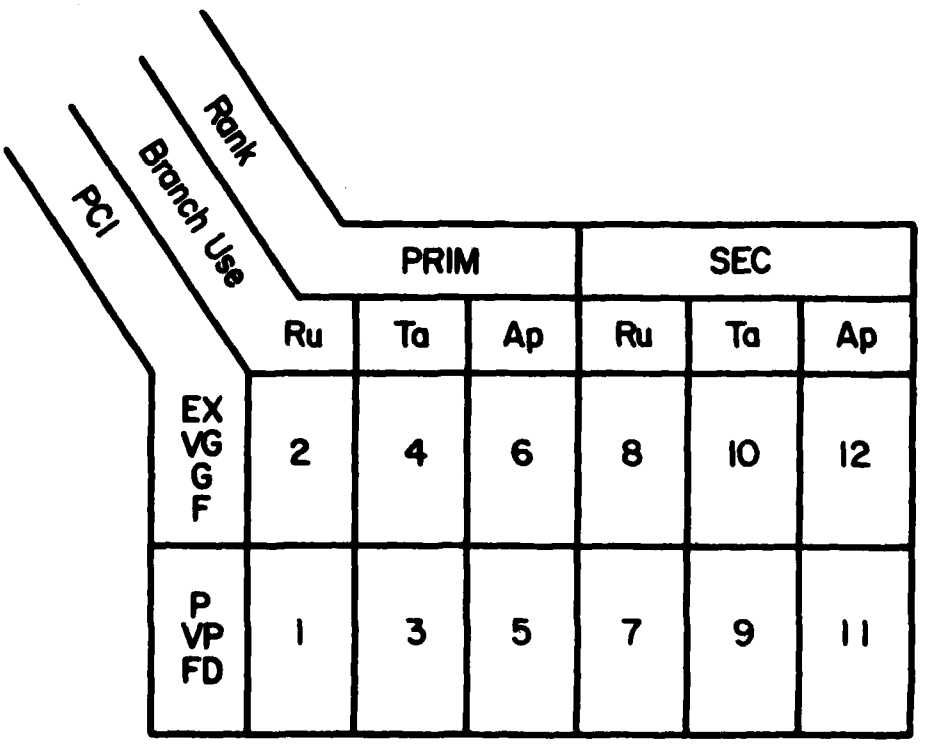



**FIGURE 7. PRIORITIZATION SCHEME.**

PCI FREQUENCY REPORT

Agency Name:

Report Date: OCT/06/1986

Branch Use : All
Pavement Rank : All
Surface Type : All
Zone : All
Section Category : All
Last Construction Date: All
PCI : All

TABLE OF PCI FREQUENCY REPORT

YEAR: NOV 1990

| CONDITION | PCI RANGE | NUMBER OF SECTIONS | % OF SECTIONS | TOTAL AREA | % OF AREA |
|---|---|---|---|---|---|
| FAILED | 0 - 10 | 1 | 33.33 | 25000 | 33.33 |
| VERY POOR | 11 - 25 | 0 | .00 | 0 | .00 |
| POOR | 26 - 40 | 2 | 66.67 | 50000 | 66.67 |
| FAIR | 41 - 55 | 0 | .00 | 0 | .00 |
| GOOD | 56 - 70 | 0 | .00 | 0 | .00 |
| VERY GOOD | 71 - 85 | 0 | .00 | 0 | .00 |
| EXCELLENT | 86 - 100 | 0 | .00 | 0 | .00 |

TOTAL NUMBER OF SECTIONS: 3
AVERAGE PCI : 22
TOTAL SECTION AREA : 75000
NUMBER OF MISSING VALUES: 0

**FIGURE 8. PCI FREQUENCY REPORT.**

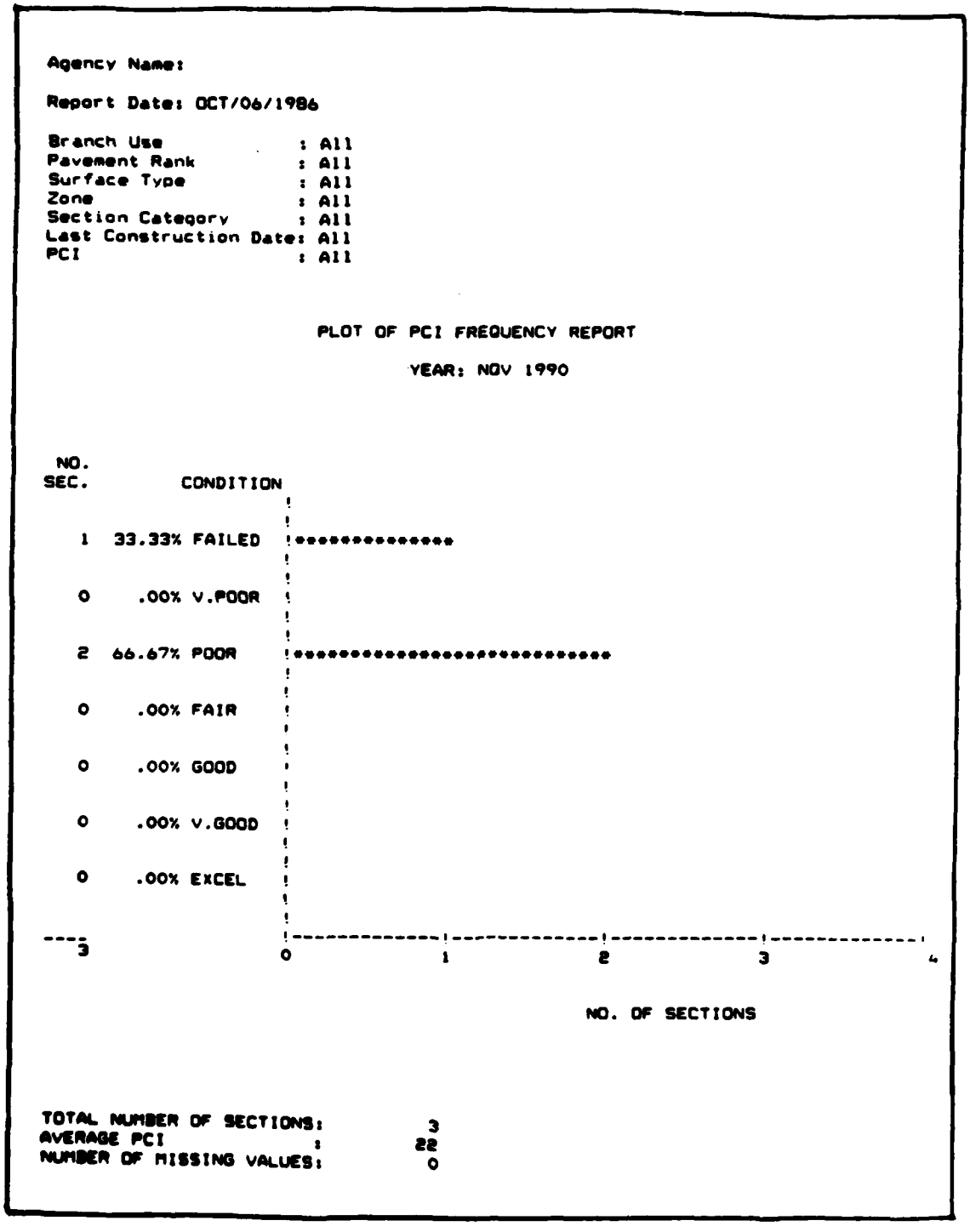



FIGURE 8. (CONT'D).

Agency Name:

Report Date: OCT/06/1986

Branch Use : All
Pavement Rank : All
Surface Type : All
Zone : All
Section Category : All
Last Construction Date: All
PCI : All

SECTION LIST OF PCI FREQUENCY REPORT

YEAR: NOV 1990

| BRANCH NUMBER/ USE / NAME | SECTION NUM /RANK/SURF/ | AREA | LAST INSPECTION | LAST PCI | PRED PCI |
|---|---|---|---|---|---|
| R1231 / RUNWAY / RUNWAY 12-31 | B1 / P / PCC/ | 25000 | SEP/30/1980 | 68 | 0 |
| R1231 / RUNWAY / RUNWAY 12-31 | A1 / P / PCC/ | 25000 | SEP/30/1985 | 55 | 29 |
| R1231 / RUNWAY / RUNWAY 12-31 | C1 / P / PCC/ | 25000 | SEP/30/1984 | 65 | 38 |

TOTAL NUMBER OF SECTIONS: 3
AVERAGE PCI : 22
NUMBER OF MISSING VALUES: 0

FIGURE 8. (CONT'D)

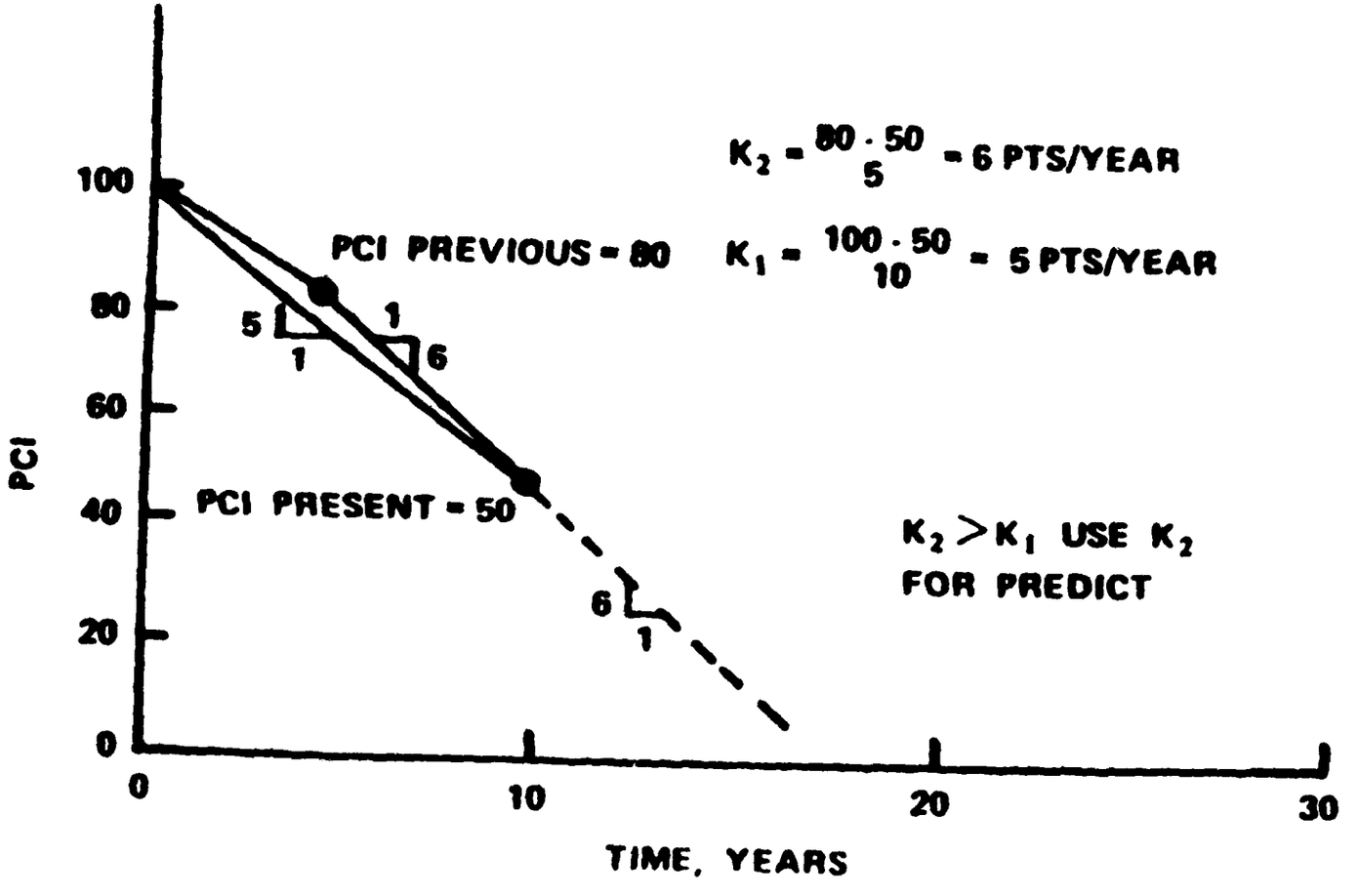



FIGURE 9. PCI PREDICTION TECHNIQUE.

Budget Planning Report

Agency Name:
Report Date: JUL/21/1987

| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |
| Inflation Rate | : 7.00 % |

Table of Budget Planning Report
(Costs in thousands of dollars)

| Pavement Rank | Year to Repair 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Primary | 2100.00 | 1249.80 | 103.04 | 4375.42 | 344.08 | .00 |
| Total Cost | 2100.00 | 1249.80 | 103.04 | 4375.43 | 344.08 | .00 |

| | |
|---|---|
| Total Number of Sections Repaired | : 15 |
| Total Number of Sections Not Needing Repair | : 6 |
| Total Number of Missing Values | : 0 |

**FIGURE 10. BUDGET PLANNING REPORT.**

Budget Planning Report

Agency Name:
Report Date: JUL/21/1987

| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |
| Inflation Rate | : 7.00 % |

Plot of Budget Planning Report

| Cost of Repair | Year to Repair | |
|---|---|---|
| 2100.00 | 1988 | ********** |
| 1249.80 | 1989 | ********** |
| 103.04 | 1990 | * |
| 4375.43 | 1991 | ********** |
| 344.08 | 1992 | **** |
| .00 | 1993 | |
| 8172.35 | | 0 1094 2188 3282 4376 |

Cost in Thousands

| | |
|---|---|
| Total Number of Sections Repaired | : 15 |
| Total Number of Sections Not Needing Repair | : 6 |
| Total Number of Missing Values | : 0 |

**FIGURE 10. (CONT'D).**

Budget Planning Report

Agency Name:
Report Date: JUL 21 1987

| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |
| Inflation Rate | : 7.00 % |

Section List of Budget Planning Report
(Costs in thousands of dollars)

| Year to Repair | Branch Num / Use | Section Num / Rank / Surf | Pred PCI | $/SF | Section Area(SF) | Cost ($1000's |
|---|---|---|---|---|---|---|
| 1988 | ARR09 / RUNWAY | 09 / P / AC | 61 | 3.45 | 120000 | 414.0 |
| 1988 | ARRTB / TAXIWAY | 42 / P / AC | 8 | 6.00 | 90000 | 540.0 |
| 1988 | ARTA / TAXIWAY | 06 / P / AC | 19 | 5.55 | 45000 | 249.75 |
| 1988 | ARTA / TAXIWAY | 08 / P / AC | 38 | 4.60 | 70000 | 322.0 |
| 1988 | ARTA / TAXIWAY | 10 / P / AC | 30 | 5.00 | 100000 | 500.0 |
| 1988 | ARTA1 / TAXIWAY | 07 / P / AC | 24 | 5.30 | 5000 | 26.5 |
| 1988 | ARTA2 / TAXIWAY | 01 / P / AC | 49 | 4.05 | 5000 | 20.25 |
| 1988 | ARTB2 / TAXIWAY | 04 / P / AC | 20 | 5.50 | 5000 | 27.5 |
| 1989 | ARR09 / RUNWAY | 01 / P / AC | 66 | 3.20 | 220000 | 753.28 |
| 1989 | ARR09 / RUNWAY | 06 / P / AC | 71 | 2.90 | 27600 | 85.6 |
| 1989 | ARR09 / RUNWAY | 08 / P / AC | 66 | 3.20 | 120000 | 410.88 |
| 1990 | ARAEE / APRON | 02 / P / AC | 58 | 3.60 | 25000 | 103.0 |
| 1991 | A2 / APRON | AC / P / PCC | 59 | 3.55 | 873000 | 3796.59 |
| 1991 | A2 / APRON | D2 / P / PCC | 60 | 3.50 | 135000 | 578.83 |
| 1992 | ARAEE / APRON | 07 / P / AC | 60 | 3.50 | 75000 | 344.08 |

| | |
|---|---|
| Total Number of Sections Repaired | : 15 |
| Total Number of Sections Not Needing Repair | : 6 |
| Total Number of Missing Values | : 0 |

**FIGURE 10. (CONT'D).**

Budget Planning Report

Agency Name:
Report Date: JUL 21 1987

| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |
| Inflation Rate | : 7.00 % |

Summary of Data for the Budget Planning Report

Minimum PCI Table

| Branch Use | Pavement Rank | Year of Repair 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|---|
| APRON | P | 50 | 55 | 60 | 60 | 60 | 60 |
| RUNWAY | P | 70 | 75 | 75 | 80 | 80 | 80 |
| TAXIWAY | P | 55 | 55 | 60 | 65 | 70 | 70 |

Unit Repair Cost Table
(Cost in $/SF)

| Surface Type | 0-20 | 21-40 | 41-60 | 61-80 | 81-100 |
|---|---|---|---|---|---|
| AC | 6.00 | 5.00 | 4.00 | 3.00 | 1.00 |
| PCC | 8.00 | 6.00 | 4.00 | 3.00 | 2.00 |

**FIGURE 10. (CONT'D)**

Inspection Schedule Report

Agency Name:
Report Date: JUL/21/1987

| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |

Table of Inspection Schedule Report

| Pavement Rank | Year to Inspect 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|---|---|---|---|---|---|---|
| Primary | 14 | 5 | 2 | 0 | 0 | 0 |
| Total Sections to Inspect | 14 | 5 | 2 | 0 | 0 | 0 |

| | |
|---|---|
| Total Number of Sections to Inspect | : 21 |
| Total Number of Sections Not Needing Inspection | : 0 |
| Total Number of Missing Values | : 0 |

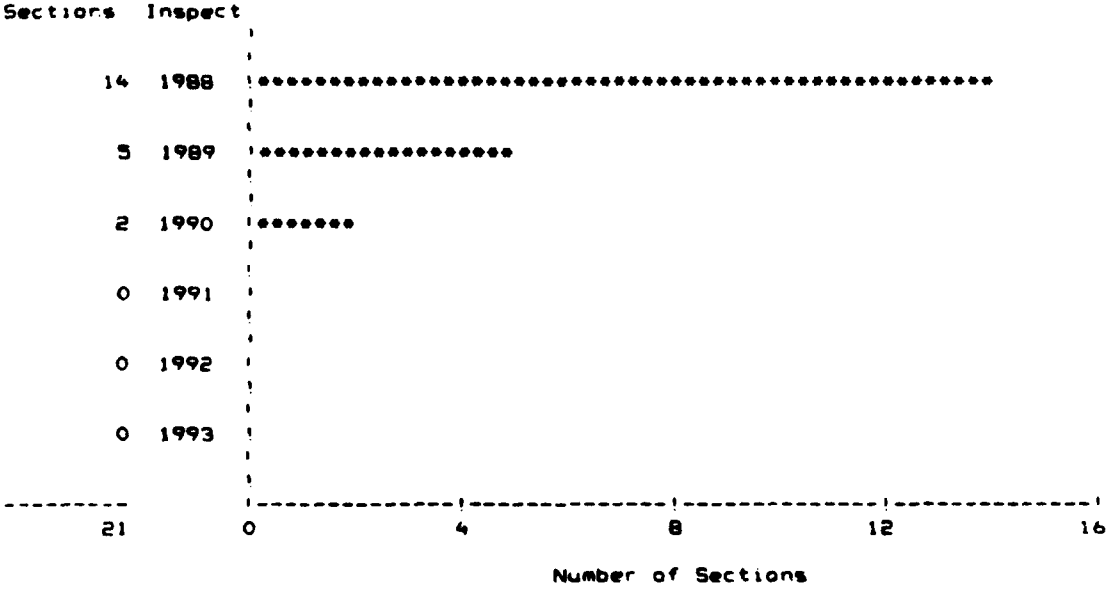
**FIGURE 11. INSPECTION SCHEDULE REPORT.**

Inspection Schedule Report

Agency Name:
Report Date: JUL/21/1987

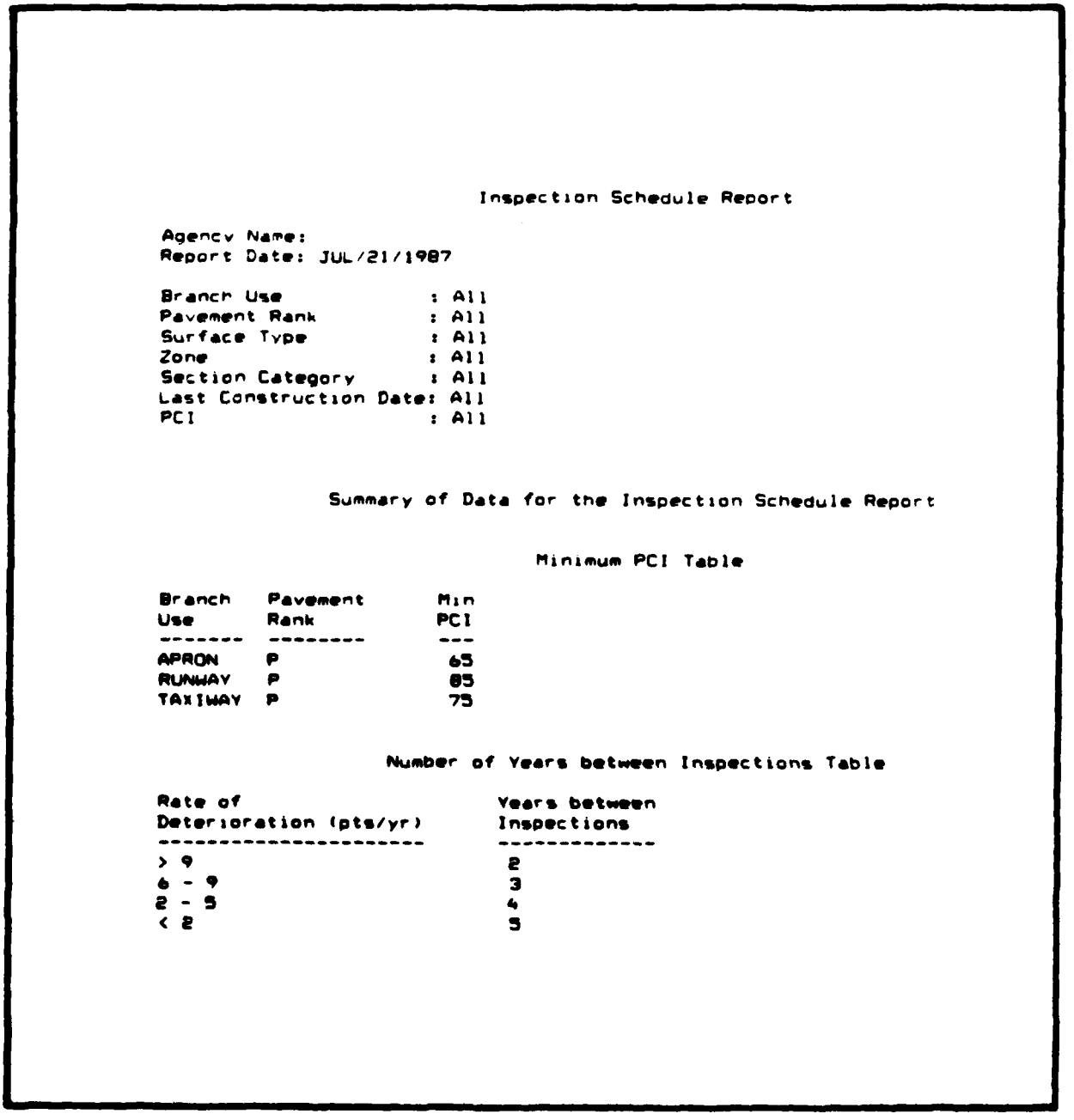
| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |

Plot of Inspection Schedule Report




| | |
|---|---|
| Total Number of Sections to Inspect | : 21 |
| Total Number of Sections Not Needing Inspection | : 0 |
| Total Number of Missing Values | : 0 |

**FIGURE 11. (CONT'D).**



Inspection Schedule Report

Agency Name:
Report Date: JUL/21/1987

| | |
|---|---|
| Branch Use | : All |
| Pavement Rank | : All |
| Surface Type | : All |
| Zone | : All |
| Section Category | : All |
| Last Construction Date | : All |
| PCI | : All |

Summary of Data for the Inspection Schedule Report

Minimum PCI Table

| Branch Use | Pavement Rank | Min PCI |
|---|---|---|
| APRON | P | 65 |
| RUNWAY | P | 85 |
| TAXIWAY | P | 75 |

Number of Years between Inspections Table

| Rate of Deterioration (pts/yr) | Years between Inspections |
|---|---|
| > 9 | 2 |
| 6 - 9 | 3 |
| 2 - 5 | 4 |
| < 2 | 5 |

**FIGURE 11. (CONT'D)**

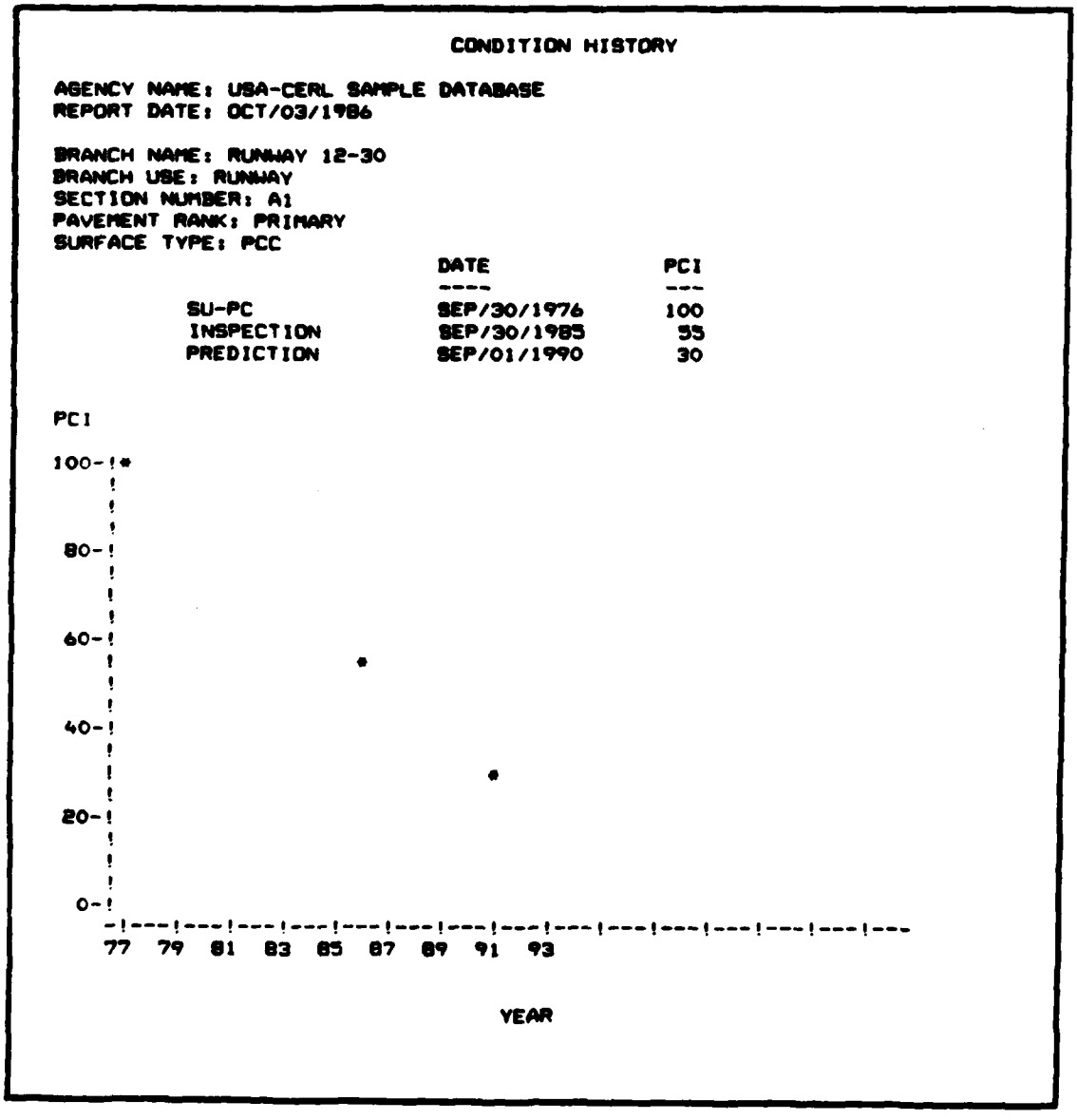



**FIGURE 12. CONDITION HISTORY REPORT.**

M & R Report

Agency Name - USA-CERL
Report Date - SEP/25/1986

Branch Name - RUNWAY 12-30
Branch Number - R1230
Section Number - B1

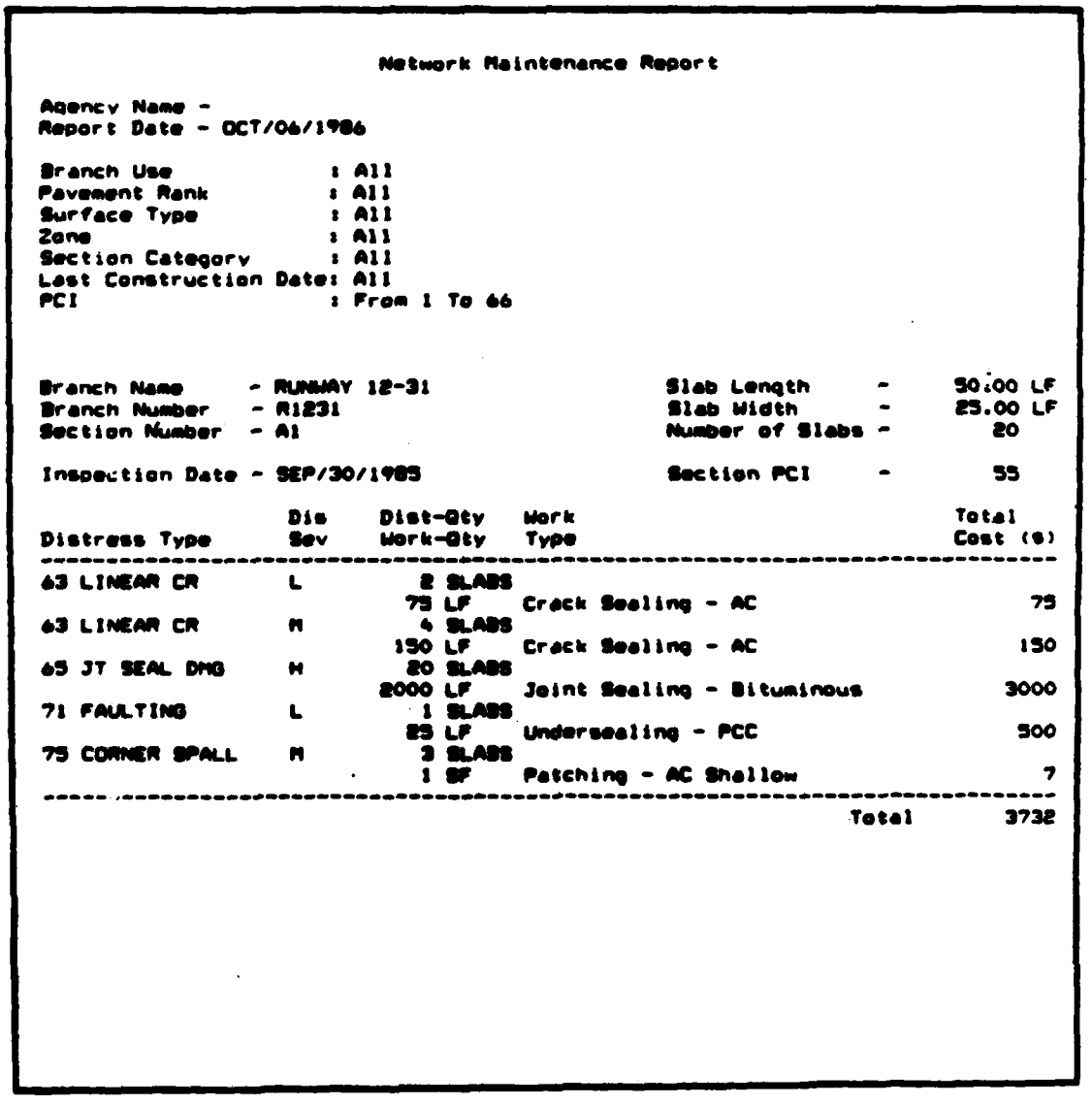
Slab Length - 20.00 LF
Slab Width - 25.00 LF
Number of Slabs - 440

Inspection Date - OCT/22/1982

Section PCI - 63

| Distress Type | Dis Sev | Dist-Qty Work-Qty | Work Type | Total Cost ($) |
|---|---|---|---|---|
| LINEAR CR | L | 250 SLABS | | |
| | | 5625 LF | Crack Sealing - PCC | 5625 |
| LINEAR CR | M | 4 SLABS | | |
| | | 90 LF | Crack Sealing - PCC | 90 |
| JT SEAL DMG | L | 440 SLABS | | |
| | | 0 LF | Joint Sealing - Bituminous | 0 |
| SMALL PATCH | L | 129 SLABS | | |
| | | 516 SF | Patching - PCC Partial Depth | 645 |
| SMALL PATCH | M | 4 SLABS | | |
| | | 16 SF | Patching - PCC Partial Depth | 200 |
| LARGE PATCH | L | 173 SLABS | | |
| | | 21625 SF | Patching - PCC Full Depth | 129750 |
| LARGE PATCH | M | 17 SLABS | | |
| | | 2125 SF | Patching - PCC Full Depth | 12750 |
| SHRINKAGE CR | | 9 SLABS | | |
| | | | -- No Maintenance Policy Available -- | |
| | | | Overlay - AC Structural | 5500000 |
| | | | Total | 5654865 |

**FIGURE 13. M&R REPORT.**



Network Maintenance Report

Agency Name -
Report Date - OCT/06/1986

Branch Use : All
Pavement Rank : All
Surface Type : All
Zone : All
Section Category : All
Last Construction Date: All
PCI : From 1 To 66

Branch Name - RUNWAY 12-31
Branch Number - R1231
Section Number - A1

Slab Length - 50.00 LF
Slab Width - 25.00 LF
Number of Slabs - 20

Inspection Date - SEP/30/1985

Section PCI - 55

| Distress Type | Dis Sev | Dist-Qty Work-Qty | Work Type | Total Cost ($) |
|---|---|---|---|---|
| 63 LINEAR CR | L | 2 SLABS<br>75 LF | Crack Sealing - AC | 75 |
| 63 LINEAR CR | M | 4 SLABS<br>150 LF | Crack Sealing - AC | 150 |
| 65 JT SEAL DMG | M | 20 SLABS<br>2000 LF | Joint Sealing - Bituminous | 3000 |
| 71 FAULTING | L | 1 SLABS<br>25 LF | Undersealing - PCC | 500 |
| 75 CORNER SPALL | M | 3 SLABS<br>1 SF | Patching - AC Shallow | 7 |
| | | | Total | 3732 |

**FIGURE 14. NETWORK MAINTENANCE REPORT.**

Agency Name -
Report Date - OCT/06/1986

Branch Use : All
Pavement Rank : All
Surface Type : All
Zone : All
Section Category : All
Last Construction Date: All
PCI : From 1 To 66

Branch Name - RUNWAY 12-31
Branch Number - R1231
Section Number - C1

Inspection Date - SEP/30/1984

Slab Length - 50.00 LF
Slab Width - 25.00 LF
Number of Slabs - 20

Section PCI - 65

| Distress Type | Dis Sev | Dist-Qty Work-Qty | Work Type | Total Cost ($) |
|---|---|---|---|---|
| 63 LINEAR CR | M | 4 SLABS | | |
| | | 150 LF | Crack Sealing - AC | 150 |
| 65 JT SEAL DMG | L | 20 SLABS | | |
| | | 2000 LF | Joint Sealing - Bituminous | 3000 |
| 71 FAULTING | L | 1 SLABS | | |
| | | 25 LF | Undersealing - PCC | 500 |
| | | | Total | 3650 |

**FIGURE 14. (CONT'D).**

Agency Name -
Report Date - OCT/06/1986

Branch Use : All
Pavement Rank : All
Surface Type : All
Zone : All
Section Category : All
Last Construction Date: All
PCI : From 1 To 66

Work Type Summary Table

| Work Type | Branch/ Section | | Work-Qty | Cost ($) |
|---|---|---|---|---|
| Crack Sealing - AC | R1231 | A1 | 225 LF | 225 |
| | R1231 | C1 | 150 LF | 150 |
| | | Total: | 375 LF | 375 |
| Joint Sealing - Bituminous | R1231 | A1 | 2000 LF | 3000 |
| | R1231 | C1 | 2000 LF | 3000 |
| | | Total: | 4000 LF | 6000 |
| Undersealing - PCC | R1231 | A1 | 25 LF | 500 |
| | R1231 | C1 | 25 LF | 500 |
| | | Total: | 50 LF | 1000 |
| Patching - AC Shallow | R1231 | A1 | 1 SF | 7 |
| | | Total: | 1 SF | 7 |

Total cost of all work ($): 7382

FIGURE 14. (CONT'D).

Policy Number: 1 Policy Description: Roads and Streets

| Distress | Sev | Work Type & Description | Cost | Unit |
|---|---|---|---|---|
| 1 ALLIGATOR CR | M | PA-AD Patching - AC Deep | 5.75 | sq. ft. |
| 1 ALLIGATOR CR | H | PA-AD Patching - AC Deep | 5.75 | sq. ft. |
| 3 BLOCK CR | H | PA-AD Patching - AC Deep | 5.75 | sq. ft. |
| 10 L & T CR | H | JS-BI Joint Sealing - Bituminous | 1.00 | ft. |
| 10 L & T CR | M | JS-BI Joint Sealing - Bituminous | 1.00 | ft. |
| 23 DIVIDED SLAB | H | PA-PF Patching - PCC Full Depth | 8.00 | sq. ft. |
| 26 JT SEAL DMG | H | JS-SI Joint Sealing - Silicon | 2.00 | ft. |
| 28 LINEAR CR | M | JS-BI Joint Sealing - Bituminous | 1.00 | ft. |
| 28 LINEAR CR | H | JS-BI Joint Sealing - Bituminous | 1.00 | ft. |
| 38 CORNER SPALL | H | PA-AS Patching - AC Shallow | 3.50 | sq. ft. |

**FIGURE 15. MAINTENANCE POLICY.**

DATE:= OCT/10/1986 PROJECTED COST ANALYSIS (DETAIL)

SECTION ID:=R1230A1

ALTERNATIVE:= 4 INCH OVERLAY SECTION AREA(S.Y.):= 2000.0
LIFE OF ALTERNATIVE:= 20 INTEREST RATE:= 7.0 INFLATION RATE:= 3.0

| M&R ACTIVITY | YEAR | COST($) | PRESENT VALUE($) |
|---|---|---|---|
| FILL MINOR CRACKS | 1986 | 2000.00 | 2000.00 |
| PLACE OVERLAY | 1986 | 53000.00 | 53000.00 |
| PAINT LANE MARKERS | 1986 | 1500.00 | 1500.00 |
| ANNUAL TOTAL:= | | 56500.00 | 56500.00 |
| FILL MINOR CRACKS | 1989 | 2000.00 | 1783.98 |
| PAINT LANE MARKERS | 1991 | 1500.00 | 1239.82 |
| FILL MINOR CRACKS | 1992 | 2000.00 | 1591.29 |
| FILL MINOR CRACKS | 1995 | 2000.00 | 1419.42 |
| PAINT LANE MARKERS | 1996 | 1500.00 | 1024.77 |
| FILL MAJOR CRACKS | 1996 | 2500.00 | 1707.95 |
| ANNUAL TOTAL:= | | 4000.00 | 2732.71 |
| FILL MAJOR CRACKS | 1997 | 2500.00 | 1644.10 |
| FILL MINOR CRACKS | 1998 | 2000.00 | 1266.11 |
| FILL MAJOR CRACKS | 1998 | 2500.00 | 1582.64 |
| ANNUAL TOTAL:= | | 4500.00 | 2848.74 |
| FILL MAJOR CRACKS | 1999 | 2500.00 | 1523.47 |
| FILL MAJOR CRACKS | 2000 | 2500.00 | 1466.52 |
| FILL MINOR CRACKS | 2001 | 2000.00 | 1129.36 |
| PAINT LANE MARKERS | 2001 | 1500.00 | 847.02 |
| FILL MAJOR CRACKS | 2001 | 2500.00 | 1411.70 |
| ANNUAL TOTAL:= | | 6000.00 | 3388.07 |
| FILL MAJOR CRACKS | 2002 | 2500.00 | 1358.92 |
| FILL MAJOR CRACKS | 2003 | 2500.00 | 1308.12 |
| FILL MINOR CRACKS | 2004 | 2000.00 | 1007.38 |
| FILL MAJOR CRACKS | 2004 | 2500.00 | 1259.22 |
| ANNUAL TOTAL:= | | 4500.00 | 2266.60 |
| FILL MAJOR CRACKS | 2005 | 2500.00 | 1212.15 |

INITIAL COST($):= 56500.00
PRESENT VALUE($):= 82283.91
EQUIVALENT UNIFORM ANNUAL COST($):= 7767.02
EUAC PER SQ. YD. ($):= 3.88

FIGURE 16. ECONOMIC ANALYSIS.

END

FEB.

1988

DTIC